* CHAPTER 15. AREA NAVIGATION (RNAV)

1500. GENERAL. This chapter applies to instrument procedures based on airborne area navigation (RNAV) systems. Separate criteria are presented for VOR/DME and non-VOR/DME RNAV systems.

a. VOR/DME Systems. This includes systems using signals based solely upon VOR/DME, VORTAC, and TACAN facilities. VOR/DME is synonymous with the terms VORTAC or TACAN.

b. Non-VOR/DME Systems.

(1) Self-contained systems, including inertial (INS) and Doppler.

(2) Satellite systems, currently including only the global positioning system (GPS).

(3) Other ground-based systems, such as Loran-C, Omega, Rho-Rho, etc.

(4) Multi-sensor systems; those which use a combination of input information.

1501. TERMINOLOGY. The following terms, peculiar to RNAV procedures, are defined as follows:

a. Airport (APT) Waypoint (WP). A waypoint located on the final approach course at or abeam the first usable landing surface, which is used for construction of the final approach area for a circling-only approach.

b. Alongtrack Distance (ATD) Fix. The ATD fix is an alongtrack position defined as a distance in NM, with reference to the next waypoint.

c. Alongtrack (ATRK) Fix Displacement Tolerance. Fix displacement tolerance along the flight track.

d. Crosstrack (XTRK) Fix Displacement Tolerance. Fix displacement tolerance to the left or right of the flight track.

e. Instrument Approach Waypoint. Fixes used in defining RNAV instrument approach procedures, including the feeder waypoint (FWP), the initial approach waypoint (IAWP), the intermediate waypoint (IWP), the final approach waypoint (FAWP), the runway waypoint (RWY WP), and the airport waypoint (APT WP), when required.

f. Non-VOR/DME RNAV is not dependent upon a reference facility and will hereinafter be referred to as non-VOR/DME, which includes the following:

(1) Long Range Navigation (Loran-C). Loran-C is a radionavigation system which allows position determination by measuring the difference in time of arrival of pulses from 100 kHz transmitting stations. Groups of three to five of these stations are operated together as a "chain." Specific Loran-C criteria may be developed when performance standards reflecting the full capability of Loran-C are published. Until separate Loran-C criteria are developed, non-VOR/DME criteria apply.

(2) Omega. A low frequency navigation system using precise timed pulsed signals from eight ground transmitting stations spaced long distances apart. Limited to en route only.

(3) Global Positioning System (GPS). GPS will provide three-dimensional position and velocity information to users anywhere in the world. The position determinations are based on the measurement of the transit time of RF (radio frequency) signals from satellites in the constellation. GPS is in the testing and development stage. Specific GPS criteria may be developed when performance standards reflecting the full capability of GPS are published. Until separate GPS criteria are developed, non-VOR/DME criteria apply.

(4) Inertial Navigation System (INS). A self-contained system which utilizes gyros to determine angular motion and accelerometers to determine linear motion. They are integrated with computers to provide several conditions which include true heading, true air speed, wind, glidepath, velocity, and position.

(5) Doppler. A self-contained system which determines velocity and position by the frequency shift of a signal transmitted from the

aircraft and reflected from the surface back to the aircraft.

(6) Rho-Rho. A system based on two or more DME ground facilities.

(7) Multi-Sensor System. Based on any VOR/DME or non-VOR/DME certified approved system or a combination of certified approved systems. The non-VOR/DME criteria apply.

g. **Reference Facility.** A VOR/DME, VORTAC, or TACAN facility used for the identification and establishment of an RNAV route, waypoint, or standard instrument approach procedure.

h. **RNAV Descent Angle.** A vertical angle defining a descending flightpath from the FAF to the RWY WP.

i. **Routes.** Two subsequently related waypoints or ATD fixes define a route segment.

(1) Jet/victor routes.

(2) Random routes. Any airway not established under the jet/victor designation. This is normally used to refer to a route that is not based on VOR radials and requires an RNAV system.

j. **Runway WP.** A waypoint located at the runway threshold and used for construction of the final approach area when the final approach course meets straight-in alignment criteria.

k. **Tangent Point (TP).** The point on the VOR/DME RNAV route centerline from which a line perpendicular to the route centerline would pass through the reference facility.

l. **Tangent Point Distance (TPD).** Distance from the reference facility to the tangent point.

m. **Time Difference (TD) Corrections.** Loran-C systems use the time of signal travel from ground facilities to the aircraft to compute distance and position. The time of signal travel varies seasonally within certain geographical areas. The TD correction factor is used to correct these seasonal variations for each geographical area. RNAV criteria assume local TD corrections will be applied.

n. **Turn Anticipation.** The capability of RNAV systems to determine the point along a course, prior to a turn waypoint, where a turn should be initiated to provide a smooth path to intercept the succeeding course, and to annunciate the information to the pilot.

o. **Turn Waypoint.** A waypoint which identifies a change from one course to another.

p. **VOR/DME RNAV** is dependent on VOR/DME, VORTAC, or TACAN. It is a system using radials and distances to compute position and flight track and will hereinafter be referred to as VOR/DME.

q. **Waypoint (WP).** A predetermined geographical position used for route definition and/or progress reporting purposes that is defined by latitude/longitude. For VOR/DME systems, it is defined also by the radial/distance of the position from the reference facility.

r. **Waypoint Displacement Area.** The rectangular area formed around and centered on the plotted position of a waypoint. Its dimensions are plus-and-minus the appropriate alongtrack and crosstrack fix displacement tolerance values which are found in tables 15-1, 15-2, and 15-3.

1502. PROCEDURE CONSTRUCTION. RNAV procedural construction requirements are as follows:

a. **Reference Facility.** An RNAV approach procedure shall be supported by a single reference facility.

b. **Waypoints.** A WP shall be used to identify the point at which RNAV begins and the point at which RNAV ends, except when the RNAV portion of the procedure terminates at the missed approach point (MAP), and the MAP is an ATD fix.

c. **Segment.** Approach segments begin and end at the WP or ATD fix.

(1) The segment area considered for obstacle clearance begins at the earliest point the WP or ATD fix can be received and, except for the final approach segment, ends at the plotted position of the fix.

(2) Segment length is based on the distance between the plotted positions of the WP or ATD fix defining the segment ends.

(3) Segment width (primary and secondary areas), at the earliest point, shall be the same as the width of the adjacent preceding segment at that point. Segment widths are specified in appropriate paragraphs of this chapter, but in no case will they be narrower than XTRK fix displacement tolerances for that segment.

(4) Minimum segment widths are also determined/limited in part according to WP location relative to the reference facility. This limiting relationship is depicted in figure 15-2 and explained in the note following figure 15-2.

d. Fix Displacement. Except in the case of the MAP overlapping the RWY WP or APT WP (see paragraph 1532), the ATRK fix displacement tolerance shall not overlap the plotted position of the adjacent fix. Additionally, except for a turn at a MAP designated by a WP, WP displacement tolerances shall be oriented along the courses leading to and from the respective WP. See figure 15-17.

e. Turning Areas. Turning area expansion criteria shall be applied to all turns, en route and terminal, where a change of direction of more than 15° is involved. See paragraphs 1510c and 1520.

f. Cone of Ambiguity. The primary obstacle clearance area at the minimum segment altitude shall not be within the cone of ambiguity of the reference facility. If the primary area for the desired course lies within the cone of ambiguity, the course should be relocated or the facility flight inspected to verify that the signal is adequate within the area. FAA Order 9840.1, U.S. National Aviation Handbook for the VOR/DME/TACAN Systems, defines the vertical angle coverage. Azimuth signal information permitting satisfactory performance of airborne components is not provided beyond the following ranges:

(1) VOR - beyond 60° above the radio horizon.

(2) TACAN - beyond 40° above the radio horizon. See figure 15-1.

g. Use of ATD Fixes. ATD fixes are normally used in lieu of approach waypoints when no course change is required at that point. An ATD fix shall not be used in lieu of a RWY WP. The final approach fix (FAF), MAP, and any stepdown fixes may be defined by ATD fixes. Consistent with operational need, flyability, and fix displacement tolerance overlap restrictions, there is no maximum number of stepdown fixes in any segment. Multiple stepdown fixes shall be defined in whole nautical mile (NM) increments.

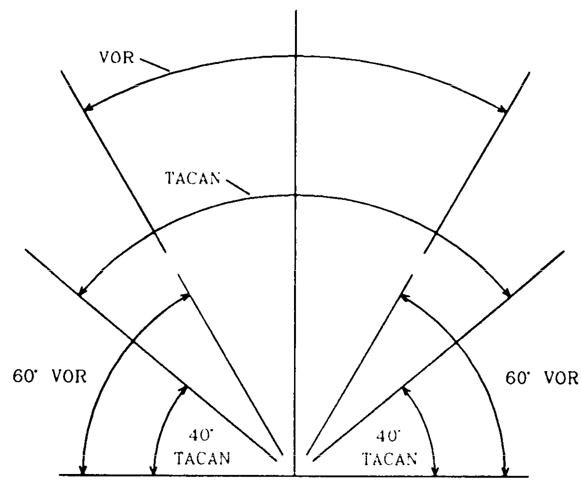


Figure 15-1. CONES OF AMBIGUITY.
Paragraph 1502.

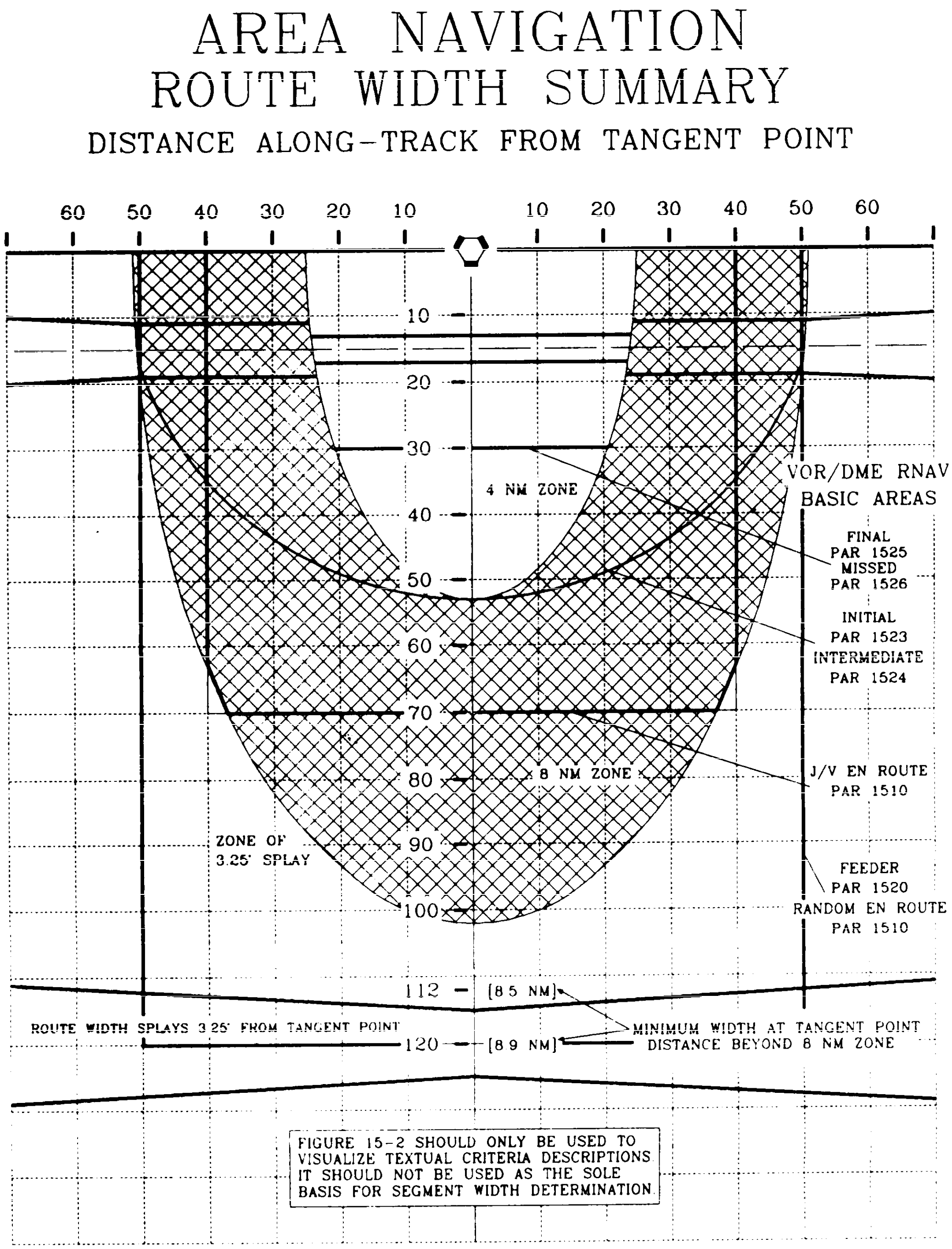


Figure 15-2
Paragraph 1502

NOTE: Segment width (for instance at a specific WP) is based upon a mathematical relationship between TPD, and the ATD from the TP, at that point. This relationship is represented by the two elliptical curves shown on figure 15-2. One curve encloses the "4 NM ZONE" wherein the segment primary area width is ± 2 miles from route centerline. The other curve encloses the "8 NM ZONE" wherein the segment primary area width is ± 4 miles from route centerline.

The formula for the 4 NM ZONE curve is: $\frac{X^2}{(25.5)^2} + \frac{Y^2}{(53)^2} = 1$

The formula for the 8 NM ZONE curve is: $\frac{X^2}{(51)^2} + \frac{Y^2}{(102)^2} = 1$

where X = ATD from the TP
and, Y = TPD

APPLICATION:

4 NM ZONE: To determine the maximum acceptable ATD value associated with a given TPD value and still allow segment primary width at ± 2 miles.

Given: TPD = 40 miles (this is the Y-term)
Find: ATD value (this is the X-term)

$$X = 25.5 \quad 1 - \frac{Y^2}{(53)^2}$$

$$X = 25.5 \quad 1 - \frac{(40)^2}{(53)^2} = 16.73 \text{ miles}$$

i.e., for TPD at 40 miles, if the ATD exceeds 16.73 miles, the primary area width must be expanded to ± 4 miles.

8 NM ZONE: Given: ATD = 30 miles
Find: TPD Maximum for ± 4 miles width

$$Y = 102 \quad 1 - \frac{X^2}{(51)^2}$$

$$Y = 102 \quad 1 - \frac{(30)^2}{(51)^2} = 82.49 \text{ miles}$$

i.e., for ATD at 30 miles, the TPD must not exceed 82.49 miles and still allow ± 4 miles width.

APPLICATION: The formulas can tell you whether the specific point is inside or outside either zone area. For instance:

Given: ATD = 40 miles, and TPD = 65 miles.
Determine if the location is within the 8 NM ZONE.

The basic formula for the 8 NM ZONE is an equation made equal to 1. By substituting the specific values (ATD = 40, and TPD = 65), the point will be determined to be OUTSIDE the zone if the resultant is > 1, and INSIDE the zone if the resultant is < or = to 1.

$$\frac{X^2}{(51)^2} + \frac{Y^2}{(102)^2} = 1$$

by substitution:

$$\frac{(40)^2}{(51)^2} + \frac{(65)^2}{(102)^2} = 0.615 + 0.406 = 1.021$$

Since this is > 1, the point lies OUTSIDE the 8 NM ZONE.

For distances beyond 102 miles of the TPD, the route width expands an additional 0.25 miles each side of the route centerline for each 10 miles the TPD is beyond 102 miles.

Example: 112-102 = 10 NM beyond TPD 102.

a. (10 NM/10 NM) x .25 NM (rate per 10 NM) = 0.25 increase.

b. 0.25 NM + 4 NM = 4.25 NM each side centerline.

c. 4.25 x 2 = 8.5 NM (total width) at the 112 TPD.

h. Positive Course Guidance. All RNAV segments shall be based on positive course guidance, except that a missed approach segment without positive course guidance may be developed when considered to provide operational advantages and can be allowed within the obstacle environment.

1503. IDENTIFICATION OF RNAV INSTRUMENT APPROACH PROCEDURES (IAP). Instrument approach procedures based on RNAV are identified by a prefix describing the navigational system followed by the term RNAV and runway number/letter as appropriate; i.e., LORAN RNAV RWY 20, VOR/DME RNAV RWY 20, GPS RNAV RWY 20, RIIO-RIIO RNAV RWY 20, MULTI-SENSOR RNAV RWY 20, or LORAN RNAV-A.

1504. REFERENCE FACILITIES. Reference facilities shall have collocated VOR and DME components. For terminal procedures, components within 100 feet of each other are defined as collocated. For en route procedures, components within 2,000 feet of each other are defined as collocated.

1505. WAYPOINTS. RNAV waypoints are used for navigation reference and for air traffic control operational fixes, similar to VOR/DME ground stations, and intersections used in the conventional VOR structures.

a. Establishment. Waypoints shall be established along RNAV routes at the following points:

(1) At end points;

(2) At points where the route changes course;

(3) At holding fixes; and,

(4) At other points of operational benefit, such as route junction points which require clarity.

(5) For VOR/DME WP's, one WP must be associated with each reference facility used for en route navigation requirements. If a segment length exceeds 80 miles and no turning requirement exists along the route, establish a WP at the TP.

b. WP. WP placement is limited by the type of RNAV system as follows:

(1) No VOR/DME WP's or route segments shall be established outside of the service volume of the reference facility and shall be limited to the values contained in tables 15-1 and 15-2.

(2) No non-VOR/DME WP's or route segments shall be established outside of the area in which the particular system signal has been approved for IFR operation.

(3) Self-contained systems such as INS and Doppler do not have limitations on WP placement.

(4) Fix Displacement Tolerances. Tables 15-1 and 15-2 show fix displacement tolerances for VOR/DME systems. Table 15-3 shows fix displacement tolerances for non-VOR/DME systems. When the fix is an ATD fix, the alongtrack fix and crosstrack displacement tolerances are considered to be the same as a WP located at that fix.

c. **Defined WP Requirements.**

(1) VOR/DME WP's. Each WP shall be defined by:

(a) A VOR radial - developed to the nearest hundredth of a degree;

(b) DME distance - developed to the nearest hundredth of a mile; and

(c) Latitude/longitude - in degrees, minutes, and seconds to the nearest hundredth.

(2) Non-VOR/DME WP's. Each WP shall be defined by latitude and longitude in degrees, minutes, and seconds developed to the nearest hundredth. Rho-Rho WP's shall also be developed to the nearest hundredth of a mile.

(3) Station elevation of the reference facility shall be defined and rounded to the nearest 20-foot increment.

1506. RWY WP AND APT WP. Straight-in procedures shall incorporate a WP at the runway threshold. Circling procedures shall incorporate an APT WP at or abeam the first usable landing surface. See figure 15-3. These WP's are used to establish the length and width of the final approach area.

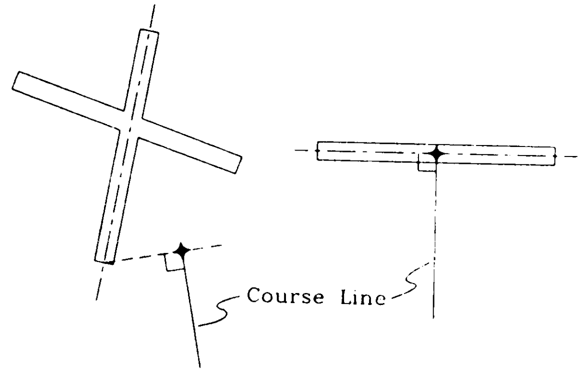


Figure 15-3. LOCATION OF AIRPORT WP.
Paragraph 1506.

1507. HOLDING. Chapter 2, section 9, applies, except for paragraph 292d. When holding is at an RNAV fix, the selected pattern shall be large enough to contain the entire area of the fix displacement tolerance within the primary area of the holding pattern.

a. **VOR/DME Pattern Size Selection.** For VOR/DME, the distance from the WP to the reference facility shall be applied as the "fix-to-NAVAID distance" in FAA Order 7130.3, Holding Pattern Criteria, figure 3, pattern-template selection.

b. **Non-VOR/DME Pattern Size Selection.** For non-VOR/DME, use the 15-29.9 NM distance column for terminal holding procedure and 30 NM or over column for en route holding, FAA Order 7130.3.

1508-1509. RESERVED.

SECTION 1. EN ROUTE CRITERIA.

1510. EN ROUTE OBSTACLE CLEARANCE AREAS. En route obstacle clearance areas are identified as primary and secondary. These designations apply to straight and turning segment obstacle clearance areas. The required angle of turn connecting en route segments to other en route, feeder, or initial approach segments, shall not exceed 120°. Where the turn exceeds 15°, expanded turning area construction methods in paragraph 1510c apply.

a. Primary Area. The primary obstacle clearance area is described as follows:

(1) VOR/DME Basic Area. The area is 4 miles each side of the route centerline, when the TPD is 102 miles or less and the TPD/ATD values do not exceed the limits of the 8 NM zone. The route width increases at an angle of 3.25° as the ATD increases for that portion of the area where the route centerline lies outside the 8 NM zone. See figure 15-4. When the TPD exceeds the 102-mile limit, the minimum width at the TPD expands greater than ± 4 miles at a rate of 0.25 miles on each side of the route for each 10 miles the TPD is beyond 102 miles. See figures 15-2, 15-5, and table 15-1. When the widths of adjoining route segments are unequal for reasons other than transition of zone boundaries, the following apply:

(a) If the TP of the narrower segment is on the route centerline, the width of the narrower segment includes that additional airspace within the lateral extremity of the wider segment, where the route segments join, thence toward the TP of the narrower route segment until intersecting the boundary of the narrower segment. See figure 15-6.

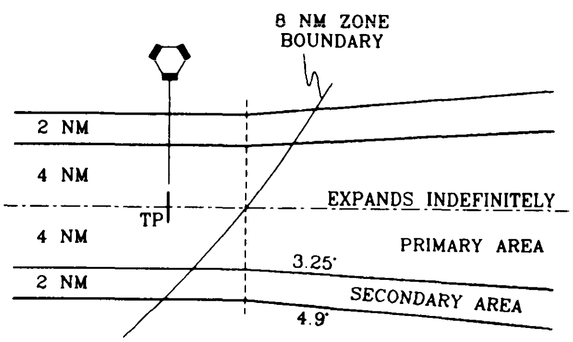


Figure 15-4. VOR/DME
BASIC AREA
Paragraphs 1510a(1), 1510b(1),
and 1512b(1)(a).

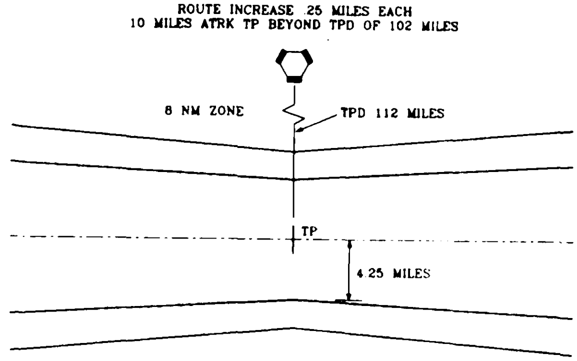


Figure 15-5. VOR/DME
BASIC AREA.
Paragraphs 1510a(1) and b(1).

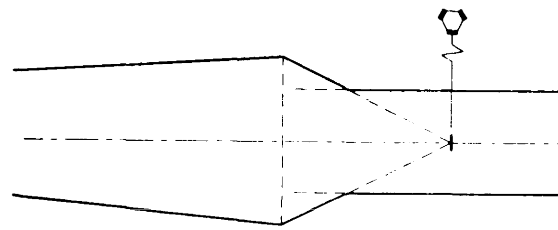


Figure 15-6.
UNEQUAL JOINING ROUTE SEGMENTS.
Paragraph 1510a(1)(a).

(b) If the TP of the narrower segment is on the route centerline extended, the width of the narrower segment includes that additional airspace within lines from the lateral extremity of the wider segment where the route segments join, thence toward the TP until reaching the point where the narrower segment terminates, changes direction, or until intersecting the boundary of the narrower segment. See figure 15-7.

(2) Non-VOR/DME Basic Area. The area is 4 miles each side of the route centerline at all points. Non-VOR/DME primary boundary lines do not splay.

(3) Termination Point. An RNAV route termination point shall be at a WP. The primary area extends beyond the route termination point. The boundary of the area is defined by an arc which connects the two primary boundary lines. The center of the arc is located at the most distant point on the edge of the WP displacement area on the route centerline. See figure 15-8.

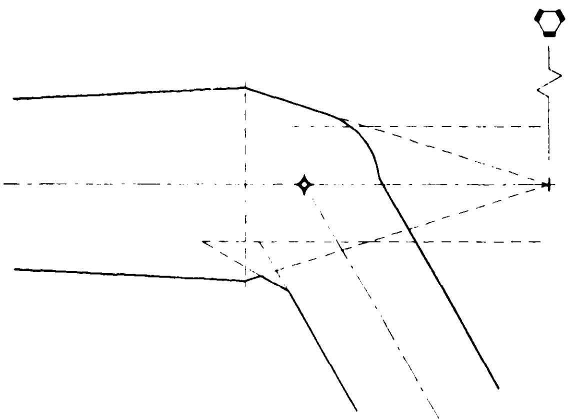


Figure 15-7. UNEQUAL JOINING ROUTE SEGMENTS WITH A TURN. Paragraph 1510a(1)(b).

b. Secondary Areas.

(1) VOR/DME Basic Area. The VOR/DME secondary obstacle clearance area extends 2 miles on each side of the primary area and splays 4.9° where the primary splays at 3.25°. See figure 15-4.

(2) Non-VOR/DME Basic Area. The non-VOR/DME secondary obstacle clearance areas are a constant 2-mile lateral extension on each side of the primary area.

(3) Termination Point. The secondary obstacle clearance area extends beyond the arc which defines the termination point primary area by an amount equal to the width of the secondary area at the latest point the waypoint can be received. See figure 15-8.

c. Construction of Expanded Turning Areas. Obstacle clearance areas shall be expanded to accommodate turns of more than 15°. The primary and secondary obstacle clearance turning areas are expanded by outside and inside areas. See figure 15-9. The inside expansion area is constructed to accommodate a turn anticipation area. Outside expansion area is provided to accommodate overshoot at high speeds and excessive wind conditions. No portion of the primary area at the minimum segment altitude may be in the cone of ambiguity for VOR/DME RNAV routes.

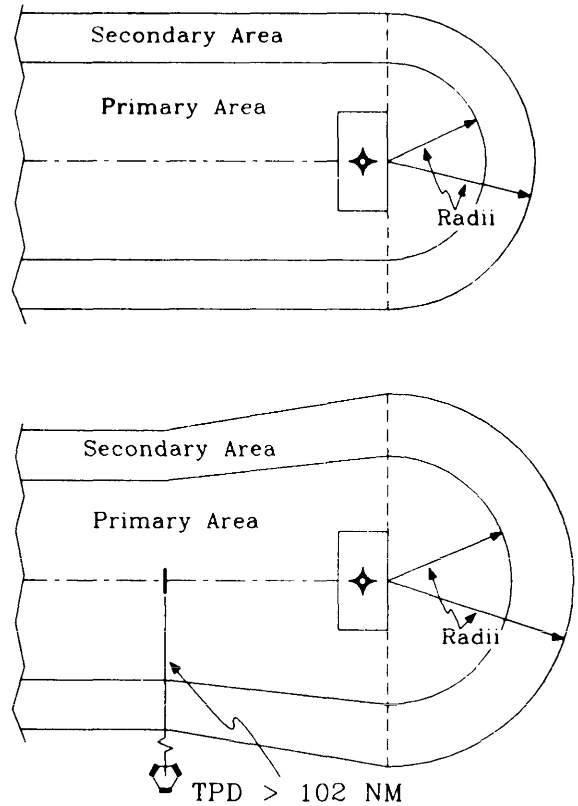
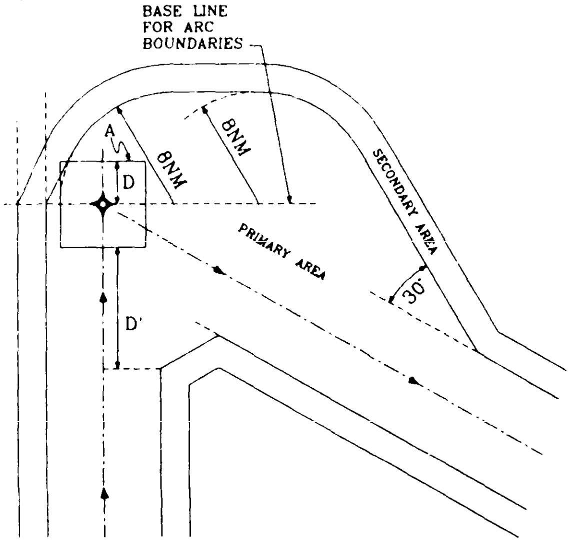


Figure 15-8. TERMINATION POINTS. Paragraphs 1510a(3) and 1510b(3).

(1) Outside Expansion Area. Determine the expanded area at the outside of the turn as follows:

(a) Construct a line perpendicular to the route centerline 3 miles prior to the latest point the fix can be received or to a line perpendicular to the route centerline at the plotted position of the fix, whichever occurs last. For altitudes 10,000 feet or greater, construct a line perpendicular to the plotted position of the fix. This perpendicular line is a base line for constructing arc boundaries.

(b) From a point on the base line, strike an 8-mile arc from the outer line of the fix displacement area on the outside of the turn to a tangent line to a second 8-mile arc. The second arc is struck from a point on the base line inside the inner line of the fix displacement area to a 30° tangent line to the primary boundary line. From a point where an extension of the base line intersects the primary area outer boundary line, connect the 8-mile arc with a line tangent to the arc.



D – 3NM FROM LINE A; HOWEVER, BASELINE IS NOT PRIOR TO PLOTTED POSITION OF FIX.
D' – IAW PARAGRAPHS 1510c(2)(b) 1. 2. AND 3

Figure 15-9. EXPANDED TURNING AREAS. Paragraph 1510c.

(c) Strike arcs from the center points used for the primary area expansion and provide a parallel expansion of 2 miles of the secondary area at the turn.

(d) Connect the extremities with a straight-line tangent to the two associated arcs.

(e) Draw the remaining secondary area boundary 2 miles outside the boundary of the primary area.

(f) If the width of the primary area at the turn point is greater than 8 miles, the expanded area is constructed in the same manner, as outlined in paragraph 1510c(1), using the primary area width at the point where the route changes course as the radius of the arc in place of 8 NM and constructing the secondary area of constant width equal to the width of the secondary area at the turn point.

(2) Inside Expansion Area. Determine the expanded area at the inside of the turn as follows:

(a) Determine the fix area by application of the ATRK and XTRK fix displacement tolerances.

(b) Prior to the earliest point the WP (oriented along the course leading to the fix) can be received, locate a point on the primary area boundary at one of the following distances:

1 Three miles below 10,000 feet MSL; three and one-half miles when the turn exceeds 112°.

2 Seven miles for 10,000 feet MSL up to but not including FL 180.

3 Twelve miles for FL 180 and above.

(c) From this point, splay the primary area by an angle equal to one-half of the course change.

(d) Draw the secondary area boundary 2 miles outside the boundary of the primary area.

d. TPD/WP Limitation. WP's for the Jet/Victor Airway structure shall be limited to the 8 NM zone, a TPD of 70 miles or less, and an ATD fix from the tangent point of 40 miles or less. WP's for random airway structure shall be limited to a TPD of 120 miles or less and an ATD fix from the tangent point of 50 miles.

e. Joining RNAV with Non-RNAV Route Segments.

(1) If the RNAV and non-RNAV segments have the same width at the point of transition, the segments are joined at that location and RNAV criteria are continued in the direction of the RNAV segment.

(2) If the RNAV segment is narrower at the location of the transition, the segments shall be joined according to paragraph 1512b(1)(b).

(3) If the RNAV segment is wider at the location of the transition, the boundaries shall taper from the transition location toward the non-

RNAV segment at an angle of 30° until joining the boundaries at the RNAV segments. If the location of transition includes a turn, the width of the RNAV segment is maintained and the turn area constructed according to this chapter. After the completion of the turn area, the boundaries shall taper at an angle of 30° until passing the non-RNAV boundaries.

1511. OBSTACLE CLEARANCE. Paragraphs 1720 and 1721 apply, except that the width of the VOR/DME secondary area is 2 miles at the point of splay initiation and the value 236 feet for each additional mile in paragraph 1721 is changed to 176 feet/NM. Non-VOR/DME systems do not splay. Obstacles in the secondary area are measured perpendicular to the course centerline, except for the expanded turn areas. Obstacles in these areas are measured perpendicular to the primary area boundary, or its tangent, to the obstacle.

1512. FEEDER ROUTES. When the initial approach WP is not part of the en route structure, it may be necessary to designate feeder routes from the en route structure to another feeder WP or the IAWP.

a. The required angle of turn for the feeder-to-feeder and feeder-to-initial segment connections shall not exceed 120°. Where the angle exceeds 15°, turning area criteria in section 2 apply. En route vertical and lateral airway obstacle clearance criteria shall apply to feeder routes. The minimum altitudes established for feeder routes shall not be less than the altitude established at the IAWP. WP's for feeder routes shall be limited to a TPD of 120 miles or less and an ATD fix from the tangent point of 50 miles or less.

b. Obstacle Clearance Areas. Obstacle clearance areas are identified as primary and secondary. These designations apply to straight segment and turning segment obstacle clearance areas.

(1) Primary Area. The primary obstacle clearance area is derived from figure 15-2 and the associated formulas. It is described as follows:

(a) VOR/DME Basic Area. The area is 4 miles each side of the route centerline when the TPD is 102 miles or less and the TPD/ATD values do not exceed the limits of the 8 NM zone. The route width increases at an angle of 3.25° as the ATD increases for that portion of the area where the route centerline lies outside the 8 NM zone. See figure 15-4. When the TPD exceeds the 102-mile limit, the minimum width at the TP increases at a rate of 0.25 miles on each side of the route centerline for each 10 miles the TPD is beyond 102 miles. Methodology for joining route segments of differing widths is contained in paragraph 1510a(1). See table 15-2.

(b) Non-VOR/DME Basic Area. The area is 4 miles each side of the course centerline at all points, except for the 20-mile portion of the course just prior to the IAWP where it tapers linearly from 4 miles to 2 miles each side of centerline. Where a WP or a fix is located less than 20 miles prior to the IAWP, the taper begins at that point. See figure 15-10.

(2) Secondary Areas.

(a) VOR/DME Basic Areas. Secondary obstacle clearance areas extend laterally 2 miles on each side of the primary area and splay 4.9° in the region where the primary area splays at 3.25°. See figure 15-11 and paragraph 1512b(1)(a).

(b) Non-VOR/DME Basic Area. Non-VOR/DME secondary areas are a constant 2-mile lateral extension on each side of the primary area, except where the basic area tapers as specified in paragraph 1512b(1)(b). Over this area, the secondary area tapers linearly from 2 miles each side of the primary to 1 mile each side of the primary area.

(3) Obstacle Clearance. Paragraph 232c applies.

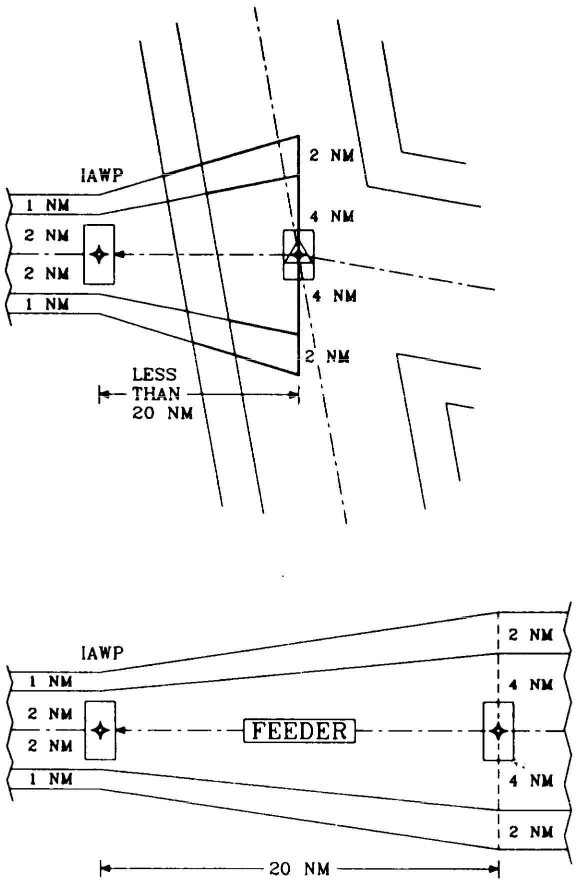


Figure 15-10. FEEDER ROUTES CONNECTING NON-VOR/DME BASIC AREAS. Paragraph 1512b(1)(b).

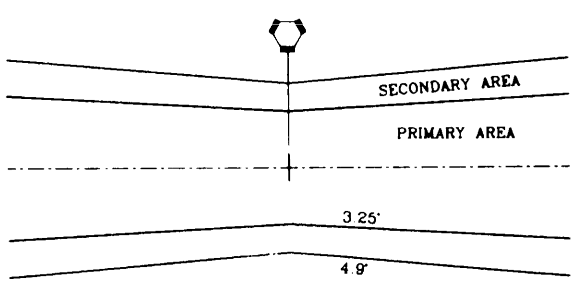


Figure 15-11. VOR/DME SECONDARY AREAS SPLAY 4.9°. Paragraph 1512b(2)(a)

1513-1519. RESERVED.

SECTION 2. TERMINAL CRITERIA.

1520. TERMINAL TURNING AREA EXPANSION. Obstacle clearance areas shall be expanded to accommodate turn anticipation. Outside expansion is not required for terminal procedures. Inside expansion applies to all turns of more than 15° within standard instrument approach procedures, except turns at the MAP. Paragraph 1529 satisfies early turn requirements for the MAP. Determine the expanded area at the inside of the turn as follows:

a. Determine the ATRK Fix Displacement Tolerance.

b. Locate a point on the edge of the primary area at a distance prior to the earliest point the WP can be received. The DTA (distance of turn anticipation) is measured parallel to the course leading to the fix and is determined by the turn anticipation formula:

$$DTA = 2 \times \tan (\text{turn angle} \div 2)$$

c. From this point, splay the primary area by an angle equal to one-half of the course change. See figure 15-12.

d. Secondary Area Boundary:

(1) When the obstacle clearance area boundaries of the preceding and following segments of the WP are parallel with the course centerline, construct the secondary area boundary, parallel with the expanded turn anticipation primary area boundary, using the width of the preceding segment secondary area.

(2) When the obstacle clearance area boundaries of the preceding and/or following segments taper, construct the secondary area boundary by connecting the secondary area at points abeam the primary expansion area where it connects to the preceding/following segments of the primary area boundaries.

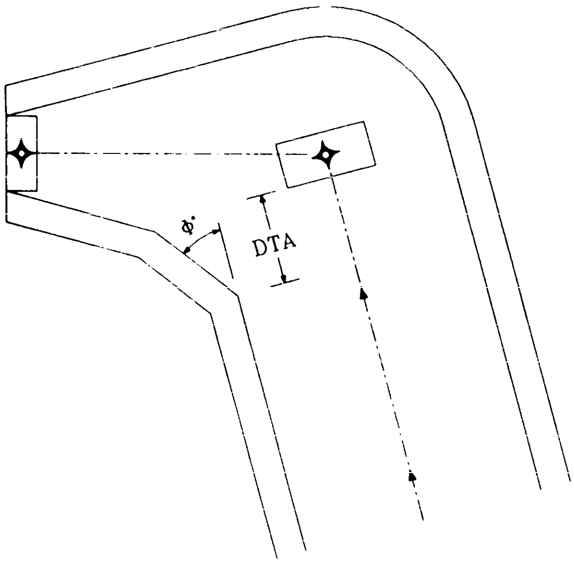


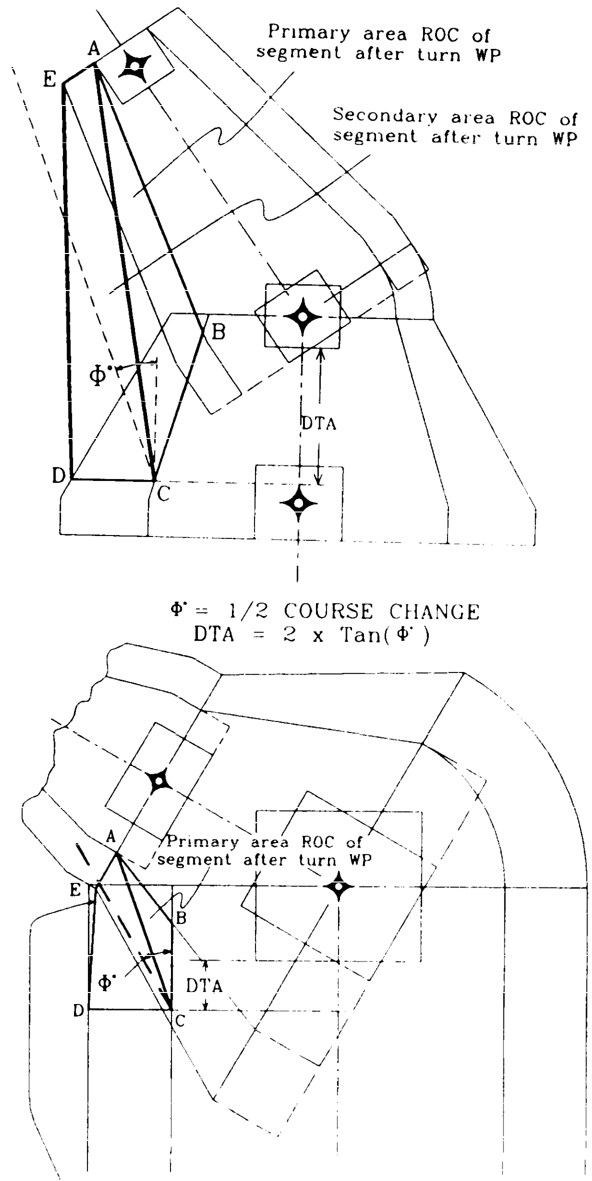
Figure 15-12. TURN ANTICIPATION SPLAY. Paragraph 1520.

e. When the boundary of the expanding turn area will not connect with the boundary of the primary area of the following segment, join the expanded area at the boundary abeam the plotted position of the next waypoint or at the latest reception point of the RWY WP or APT WP, as appropriate. See figure 15-13.

f. Obstacle Evaluation of the Expanded Area. Evaluate the primary and secondary expansion areas using the ROC for the segment following the turn waypoint. See figures 15-13 and 15-14.

1521. INITIAL APPROACH SEGMENT. The initial approach segment begins at the IAWP and ends at the IWP. See figures 15-15, 15-16, and 15-17. For VOR/DME systems, the distance from the reference facility to the IAWP shall not exceed 53 miles, nor exceed the TPD or ATD values associated with the limits of the 8 NM zone. See figure 15-2.

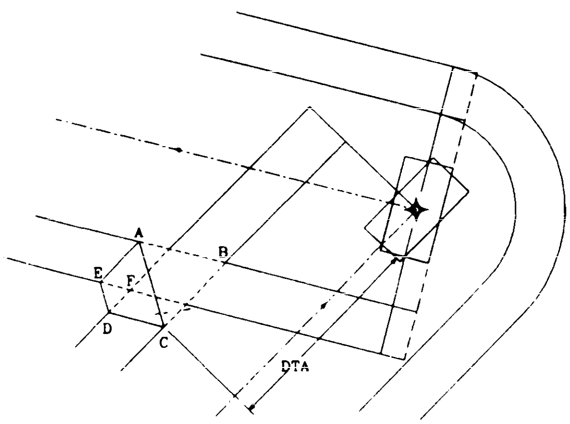
a. Alignment. The angle of intercept between the initial and intermediate segment shall not exceed 120°.



NOTE: Secondary area boundary line for expanded area. Enclosed areas A, B, C are primary areas using ROC of segment following turn WP. Enclosed areas A, C, D, E are secondary areas using ROC of segment following turn WP. Obstacle slope in these areas are perpendicular to lines AC.

Figure 15-13. SHALLOW-ANGLED TURN ANTICIPATION ILLUSTRATIONS. TAPERING INTERMEDIATE AND CONSTANT WIDTH SEGMENT. ROC APPLICATIONS. Paragraphs 1520e and f.

b. Course Reversal. When the procedure requires a course reversal, a holding pattern shall be established in lieu of a procedure turn. Paragraph 1507 applies. If holding is established over the FAF, the FAF shall be a WP, and paragraph 234e(1) applies. The course alignment shall be within 15° of the final approach course. If holding is established over the IWP, paragraph 234e(2) applies. The course alignment shall be within 15° of the intermediate course. Where a feeder segment leads to the course reversal, the feeder segment shall terminate at the plotted position of the holding WP. See figure 15-15.



Enclosed area A, B, C is primary area ROC of segment following turn WP. Area A, C, D, E is secondary area ROC of segment following turn WP. Obstacle slope in this area is perpendicular to line A-C.

Figure 15-14. TURN ANTICIPATION AREAS. Paragraph 1520f.

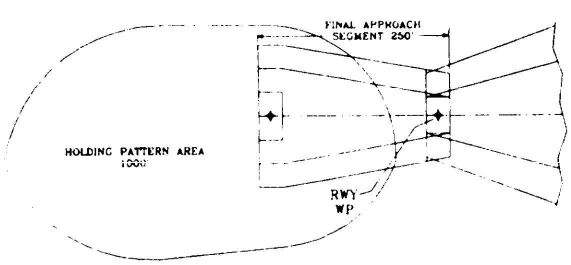


Figure 15-15. HOLDING PATTERN AND FINAL APPROACH, AND ASSOCIATED ROC. Paragraph 1521b.

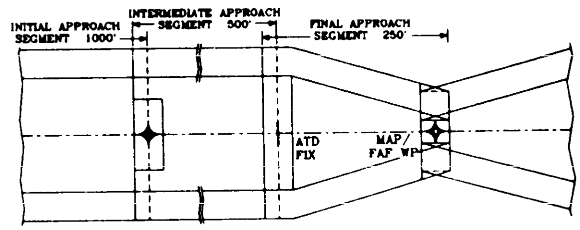


Figure 15-16. INITIAL, INTERMEDIATE, FINAL APPROACH, AND ASSOCIATED ROC. Paragraphs 1521, 1522, 1523.

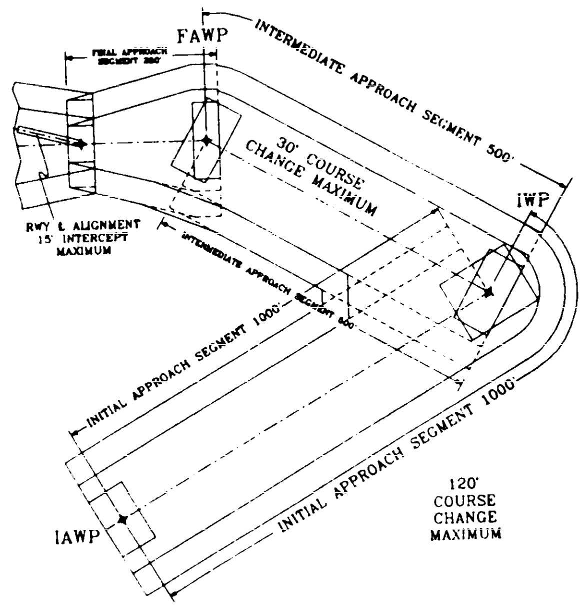


Figure 15-17. INITIAL, INTERMEDIATE, FINAL APPROACH, AND ASSOCIATED ROC. Paragraphs 1521, 1522, and 1523.

c. Area.

(1) Length. The initial approach segment has no standard length. It shall be sufficient to permit any altitude changes required by the procedure and shall not exceed 50 miles unless an operational requirement exists.

(2) Width.

(a) Primary area:

1 VOR/DME. See figure 15-18.

a In the 8 NM zone, the area is 4 NM on each side of the centerline.

b In the 4 NM zone, the area is 2 NM on each side of the centerline.

c A 30° splay connects the area boundaries, beginning where the route centerline crosses the 4 NM zone and splaying out as the ATD increases until reaching 4 NM each side of the centerline. In addition:

(1) If the splay cuts across an area of the WP fix displacement area, retain the width of the wider area and connect the wider area boundary with the narrower.

(2) If a short segment transits the 4 NM zone from the 8 NM zone and reenters the 8 NM zone, retain the 8 NM zone.

(3) If the initial approach and succeeding segments lie within the 4 NM zone, the 4 NM zone may be used throughout.

(4) Segments shall not be decreased to 2 NM widths and then increased back to 4 NM widths.

(5) The width of the primary area at the earliest point the IAWP can be received is equal to the width at the plotted position.

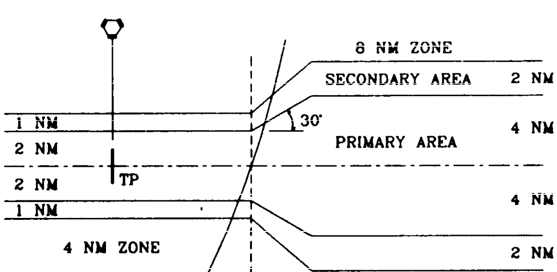


Figure 15-18. VOR/DME BASIC AREA. Paragraph 1521c(2)(a)1.

2 Non-VOR/DME - Two miles each side of centerline.

(b) Secondary area:

1 VOR/DME - The area is 1 mile each side of the primary area where the route centerline lies within the 4 NM zone. The area is 2 miles each side of the primary area where the route centerline lies within the 8 NM zone. The area boundaries are connected by straight lines abeam the same points where the primary area boundaries connect. The width of the secondary area at the earliest point the IAWP can be received is equal to the width at the plotted position.

2 Non-VOR/DME - One mile on each side of the primary area.

d. Obstacle Clearance. Paragraph 232c applies. The note in appendix 2, figure 123, 2 NM slant range, does not apply to non-VOR/DME.

e. Descent Gradient. Paragraphs 232d and 288a apply.

1522. INTERMEDIATE SEGMENT. The intermediate segment begins at the IWP and ends at the FAWP or ATD fix serving as the FAF. For VOR/DME systems, the distance from the reference facility to the IWP shall not exceed 53 miles nor exceed the TPD or ATD values associated with the limits of the 8 NM zone. See figure 15-2.

a. Alignment. The course to be flown in the intermediate segment should be the same as the final approach course. When this is not practical, the intermediate course shall not differ from the final approach course by more than 30° and an FAWP shall be established at the turn WP. See figure 15-17.

b. Area.

(1) Length. The intermediate segment shall not be less than 5 miles, nor more than 15 miles in length. If a turn is more than 90° at the IWP, table 3, chapter 2, applies.

(2) Width.

(a) Primary area:

1 VOR/DME - The width of the intermediate primary area shall equal the width of the initial primary area at the IWP. It shall either taper linearly to ± 2 miles at the FAWP or ATD fix or shall be a constant ± 2 miles, as appropriate. The width at the earliest point the IWP can be received shall equal the width at the plotted position.

2 Non-VOR/DME - Two miles on each side of centerline.

(b) Secondary area:

1 VOR/DME - The width of the intermediate secondary area shall be equal to the width of the initial secondary area at the IWP and shall either taper linearly to ± 1 mile at the FAWP or ATD fix or shall be a constant ± 1 mile, as appropriate. The width of the secondary area at the earliest point the IWP can be received shall equal the width at the plotted position.

2 Non-VOR/DME - One mile on each side of the primary area.

c. **Obstacle Clearance.** Paragraph 242c applies.

d. **Descent Gradient.** Paragraph 242d applies.

1523. FINAL APPROACH SEGMENT. The final approach segment begins at the FAWP or ATD fix and ends at the MAP. When the final approach course is a continuation of the intermediate course, an ATD fix should be used in lieu of a FAWP with additional ATD fixes established, if necessary, as stepdown fixes or the MAP. For VOR/DME systems, the FAWP/ATD fix shall be limited to a TPD of 30 miles or less and must be within the limits of the 4 NM zone shown in figure 15-2.

a. **Alignment.** The final approach course shall be aligned through the RWY or APT WP. For a straight-in approach, the alignment should be with the runway centerline. When the alignment exceeds 15°, straight-in minimums are not authorized. For a circling approach, the final approach course should be aligned to the center of the landing area, but may be aligned to any portion of the usable landing surface.

b. **Area.** The area considered for obstacle clearance starts at the earliest point the FAWP or ATD fix can be received, and for straight-in approaches, ends at the latest point of the RWY WP. For circling approaches, the area ends at the latest point of the APT WP.

(1) Length. The optimum length of the final approach segment, measured between plotted fix positions, is 5 miles. The maximum length is 10 miles. The minimum length shall provide adequate distance for an aircraft to make the required descent and to regain course alignment when a turn is required over the FAWP. Table 15-4 shall be used to determine the minimum length of the final approach segment. Fix displacement area overlap restrictions stated in paragraph 1502 apply.

(2) Width.

(a) The final approach primary area is centered on the final approach course. It is 2 miles wide on each side of the course at the earliest position the FAWP/ATD fix can be received. See figures 15-15 and 15-16. This width remains constant until the latest point the FAWP/ATD fix can be received. It then tapers to the width of the area of the XTRK fix displacement tolerance at the latest point the RWY WP or APT WP can be received. Fix displacement tolerance dimensions are shown in table 15-2 for VOR/DME systems and in table 15-3 for non-VOR/DME systems.

(b) A secondary area 1 mile wide is established on each side of the primary area. See figures 15-15 and 15-16.

c. **Obstacle Clearance.**

(1) Straight-In. The minimum required obstruction clearance (ROC) in the primary area is 250 feet. In the secondary area, the ROC of the primary area is provided at the inner edge, tapering uniformly to zero at the outer edge.

(2) Circling. A minimum of 300 feet of ROC shall be provided in the circling approach area. Paragraph 260b applies.

d. Descent Gradient. The optimum descent gradient is 300 feet-per-mile. Where a higher gradient is necessary, the maximum permissible is 400 feet-per-mile.

e. Using Fixes for Descent. Paragraphs 288a, b, c(3), c(4)(a), and 289 apply.

f. RNAV Descent Angle Information. RNAV procedures satisfying the criteria of this paragraph should be published with RNAV descent angles specified to the nearest .01°. The following constraints apply: an angle shall not be published unless the procedure is aligned within ± 0.5° of the runway centerline; there can be no obstacles penetrating the surface described in paragraph 1525f(2); an angle shall not be published for procedures with circling-only minimums; an angle shall not be published if the path would pass below the minimum descent altitude (MDA) of a segment formed using a stepdown fix.

(1) Straight-in. The RNAV descent angle shall be computed from the FAF altitude to a point 50 feet above runway threshold.

(2) Descent Angle Computation. An evaluation shall be conducted of an area the same as the precision final approach primary area, aligned with the runway centerline, using a surface at an angle of the computed RNAV descent angle for that runway, minus 1.5° commencing 200 feet outward from the runway threshold and overlying an area out to a point where the slope of the surface intercepts the altitude of the MDA minus (ROC plus adjustments). An RNAV descent angle shall not be published if this surface is penetrated by an obstacle. See figure 15-19.

Example calculations for an RNAV descent angle and the associated distance from the MDA intercept to the MAP are shown below.

(a) RNAV descent angle computation example:

Runway Elevation	1777'	FAF Altitude	3800'
Point Above RWY	+50'		-1827'
	1827'		1973'

1973 ÷ (6 x 6076.1)* = tan descent angle = 0.054119

Arctan (0.054119) = 3.098°

Published RNAV Descent Angle = 3.10°

*** Represents FAF to runway waypoint distance in feet**

(b) Calculation of the horizontal distance MDA intercept point to RWY WP example:

Runway Elevation	1777'	MDA Altitude	2040'
Point Above RWY	+50'		-1827'
	1827'		213'

213 ÷ tan 3.10° = 3,932.9' or 0.6 miles

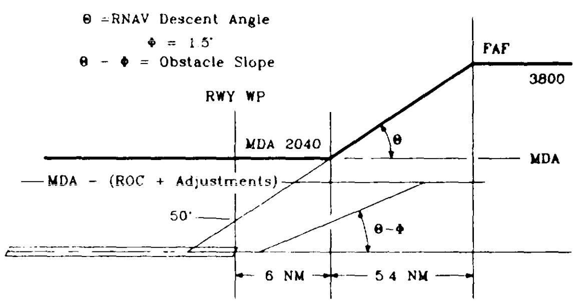


Figure 15-19. RNAV DESCENT ANGLE. Paragraph 1523f.

1524.-1529. RESERVED.

SECTION 3. MISSED APPROACH.

1530. GENERAL. For general criteria, refer to chapter 2, section 7.

1531. MISSED APPROACH SEGMENT. The missed approach segment begins at the MAP and ends at a point designated by the clearance limit. These criteria consider two types of missed approaches. They are identified as RNAV and non-RNAV missed approach procedures and defined as follows:

a. RNAV.

(1) Route. Positive course guidance provided by RNAV systems is required throughout the missed approach segment. The length of the segment is measured point-to-point between the respective (plotted position) waypoints throughout the missed approach procedure.

(a) A WP is required at the MAP and at the end of the missed approach procedure. A turn waypoint may be included in the missed approach.

(b) A straight, turning, or combination straight and turning missed approach procedure may be developed. Waypoints are required for each segment within the missed approach procedure.

(c) Turns shall not exceed 120°.

(d) A minimum leg length is required to allow the aircraft's stabilization on course immediately after the MAP. See table 15-6 for minimum distances required for each category of aircraft based on course changes.

(e) For the combination straight and turning missed approach, the straight segment shall equal or exceed the distance between the latest point the MAP can be received and the earliest point the turn WP can be received to accommodate the length of turn anticipation distance required. This segment shall be aligned within 15° of the extended final approach course.

(2) Direct. A direct missed approach may be developed to provide a method to allow the pilot to proceed to a waypoint that is not connected to the MAP by a specified course. Positive course guidance is not assumed during the entire missed approach procedure.

(a) An ATD fix may be specified as the MAP.

(b) A straight, turning, or combination straight and turning missed approach may be developed.

(c) The combination straight and turning missed approach procedure shall be a climb from the MAP to a specified altitude. The end of the straight section shall be established by an altitude, and this segment shall be aligned with the final approach course. The length of the straight section shall be determined by subtracting the lowest MDA of the procedure from the height of the turning altitude in the missed approach and multiplying by 40. The distance is measured from the latest point the MAP can be received.

(d) Turns may exceed angles of 120°.

b. Non-RNAV Missed Approach Procedures. Chapter 2, section 7, is applicable for non-RNAV missed approach criteria with the following exceptions: the connection for the missed approach area and the origination points of the 40:1 evaluation obstuction slope at the MAP, and the area for early turns begin at the earliest point the WP or ATD fix can be received. The area connects at the MAP as described in paragraphs 1532, 1533, 1534, and 1535. The tie-backs and evaluations are established and conducted as outlined in this chapter of the RNAV missed approach criteria.

1532. MISSED APPROACH POINT. The MAP shall be located on the final approach course and is normally located at the RWY WP or APT WP, as appropriate. It may be designated by an ATD fix defined relative to the distance from the RWY or APT WP. The MAP shall be no further from the FAF than the RWY or APT WP, as appropriate. The area of the MAP ATRK displacement tolerance may overlap the plotted position of the RWY or APT WP. The lateral dimensions for the area of the ATD fix are considered the same as the lateral dimensions of the primary area.

1533. STRAIGHT MISSED APPROACH. Straight missed approach criteria are applied when the missed approach course does not differ more than 15° from the final approach course.

a. Area.

(1) When the MAP is at the RWY WP or APT WP, the area starts at the earliest point the MAP can be received and has the same width as the area for the WP displacement tolerance at the RWY WP or APT WP, as appropriate. The secondary areas are 1 mile each side of the primary area at the earliest point the MAP can be received. See figure 15-20.

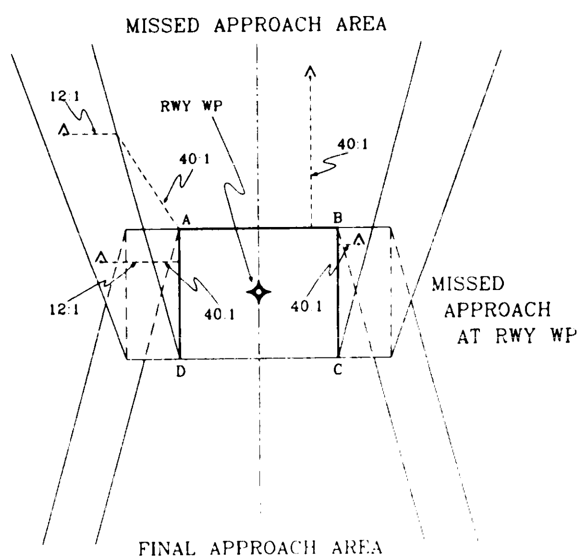


Figure 15-20. STRAIGHT MISSED APPROACH AT THE RWY WP. Paragraph 1533a(1).

(2) When the MAP is at an ATD fix, the area starts at the earliest point the MAP can be received and has the same width as the final approach primary and secondary areas at that point. See figure 15-21.

(3) The area expands uniformly to a width of 6 miles each side of the course line at a point 15 flight-track miles from the plotted position of the MAP. When positive course guidance is provided, the secondary areas splay linearly from a width of 1 mile at the MAP to a width of 2 miles at the end of the 15-mile area. The splay of these areas begins at the earliest point the MAP can be received.

(4) When a turn of 15° or less causes the outside edge of the primary missed approach boundary to cross inside the lateral dimensions of the fix displacement area of the MAP, that boundary line is then constructed from the corner of the lateral dimension of the area abeam the latest point the MAP can be received. This point is identified as point A at the MAP when represented by a WP or an ATD fix is established as the MAP. See figures 15-22 and 15-23, respectively.

b. Obstacle Clearance. The 40:1 missed approach surface begins at the edge of the area of the WP displacement tolerance or the displacement area of the ATD fix of the MAP identified as the line D-A-B-C in figures 15-20 and 15-21. For the triangular area shaded in figures 15-22 and 15-23 resulting from a skewed course of 15° or less, the 12:1 slope is measured from point A. The obstacle slope is established by measuring the shortest distance from the line D-A-B-C to the obstacle. See figures 15-22 and 15-23. The height of the missed approach surface at its beginning slope is determined by subtracting the required final approach obstacle clearance and any minima adjustments from the MDA. In the secondary area, no obstacle may penetrate the 12:1 surface extending upward and outward from the 40:1 surface at the inner boundaries at a right angle to the missed approach course.

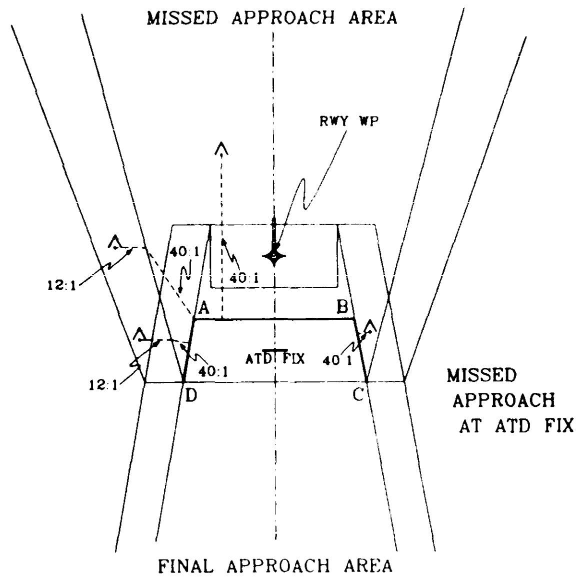


Figure 15-21. STRAIGHT MISSED APPROACH AT AN ATD FIX. Paragraph 1533a(2).

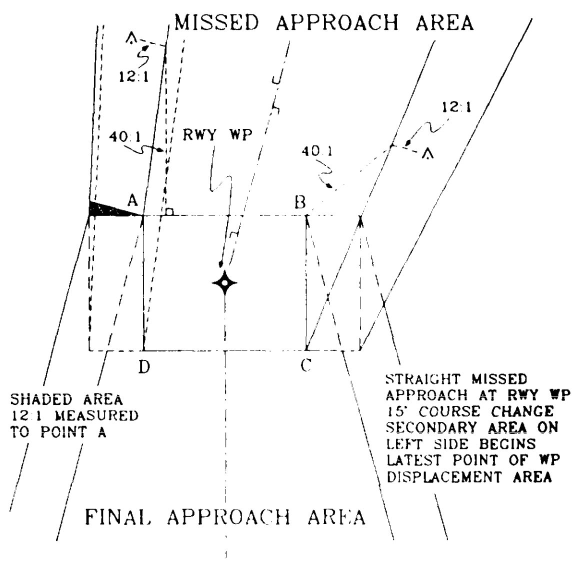


Figure 15-22. CONSTRUCTION OF STRAIGHT MISSED APPROACH WHEN TURNS ≤ 15° CAUSE OUTSIDE BOUNDARY TO CROSS INSIDE MAP FIX DISPLACEMENT TOLERANCE AT RWY WP. Paragraph 1533a(4).

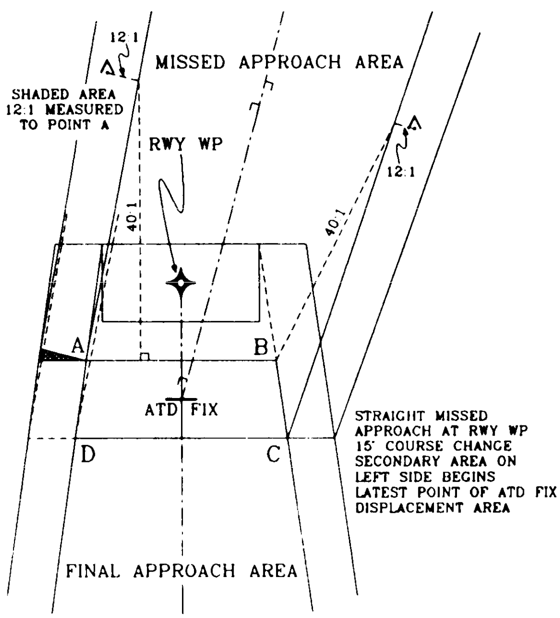


Figure 15-23. CONSTRUCTION OF STRAIGHT MISSED APPROACH WHEN TURNS ≤ 15° CAUSE OUTSIDE BOUNDARY TO CROSS INSIDE MAP FIX DISPLACEMENT TOLERANCE AT AN ATD FIX. Paragraph 1533a(4).

1534. TURNING MISSED APPROACH. Turning missed approach criteria apply whenever the missed approach course differs by more than 15° from the final approach course.

a. Area.

(1) Zone 1 begins at a point abeam the latest point the MAP can be received. See figure 15-24.

(2) The turning missed approach area should be constructed by the methods described in paragraph 275, except as follows:

(a) The radii for the outer boundary is constructed from a baseline at the latest point the MAP can be received.

(b) Where the width "d" of the final approach area at the latest point the MAP can be received exceeds the value of the radius of the outer boundary R in table 5, use "wide final approach area at the MAP" construction methodology. If the width "d" is less than or equal to R, use "narrow" methodology. See figure 15-24. Point C_1, for turns of 90° or less, connects to the WP or fix displacement area at point C, which is located at the earliest point the MAP can be received. See figures 15-25 and 15-27. Point C_1, for turns more than 90°, connects to the corner of the WP or fix displacement area at the nonturn side at point D at the earliest point the MAP can be received. See figures 15-26 and 15-28. Point C_1, for turns which expand the missed approach area boundary beyond line E-D-Z, connects to point E. See figure 15-29. Point C_1, for turns which expand the missed approach area boundary beyond line E-Z (parallel to the final approach course line), connects to point E_1, a TP of the obstacle boundary arc. See figure 15-30.

b. Obstacle Clearance. The 40:1 obstacle clearance surface begins at the edge of the WP or fix displacement area of the MAP. The height of the missed approach surface over an obstacle in zone 2 is determined by measuring a straight-line distance from the obstacle to the nearest point on the A-B-C line and computing the height based on the 40:1 ratio. See figure 15-26. The height of the missed approach surface in zone 3 is determined by measuring the distance from the obstacle to point C as shown in figure 15-26 and computing the height based on the 40:1 ratio. The height of the missed approach surface over point C for zone 3 computations is the same height as the MDA less adjustments specified in paragraphs 323a, b, and c.

1535. COMBINATION STRAIGHT AND TURNING MISSED APPROACH.

a. Area.

(1) Section 1 is a portion of the normal straight missed approach area and is constructed as specified in paragraph 15-33. See figure 15-31. The end of section 1 is based on a turn at a WP, or a climb to an altitude prior to commencing a turn.

(2) RNAV Route Missed Approach Procedure. A turn WP is used to base the length of section 1 for a route RNAV missed approach procedure.

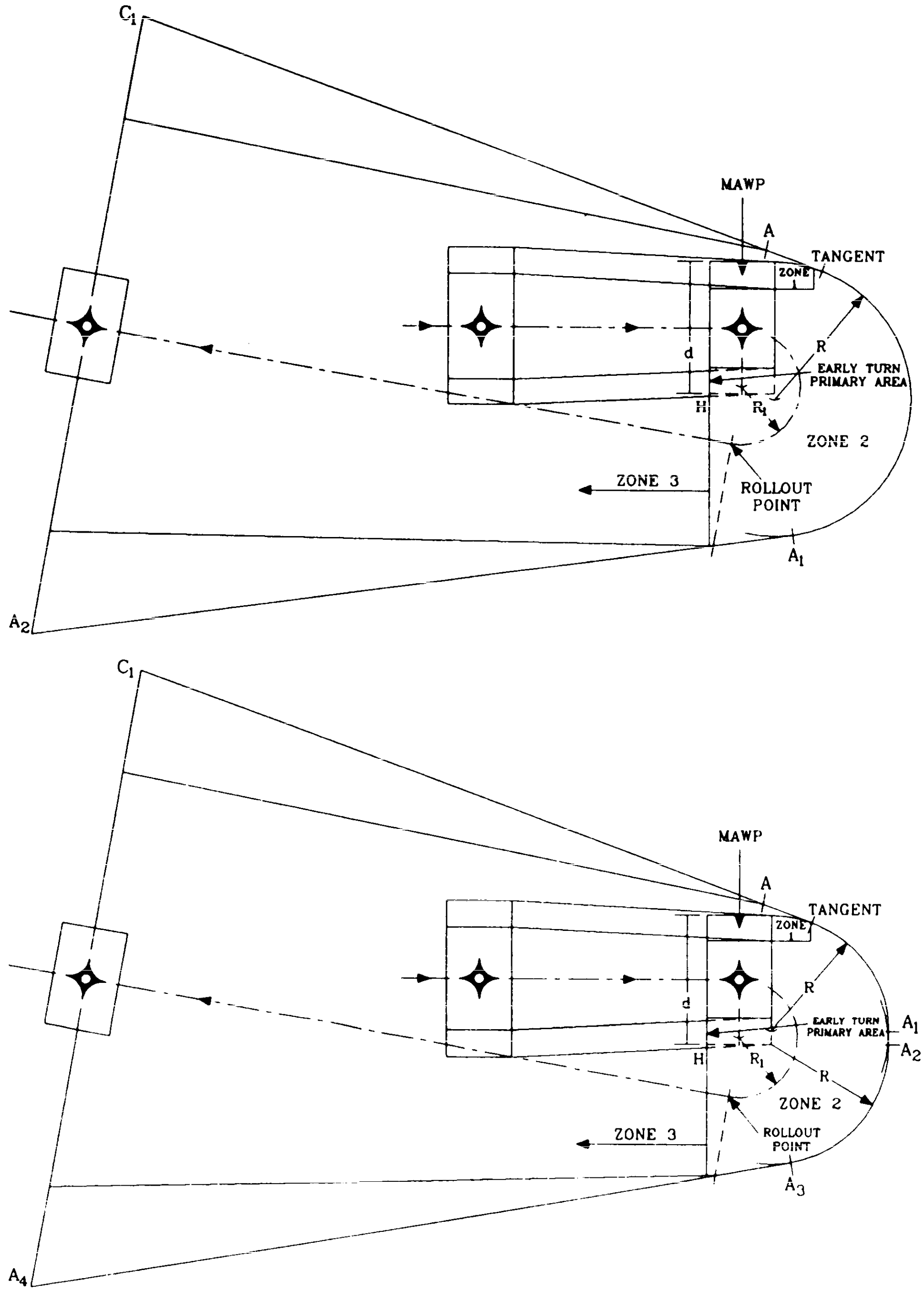


Figure 15-24. WIDE AND NARROW MISSED APPROACH METHODOLOGY.
Paragraph 1534a(2)(b).

(a) Secondary area reductions apply except where the turn exceeds 90°, when the reduction applies only on the nonturning side. See figure 15-32.

(b) For VOR/DME systems, the turn WP shall be limited to a TPD of 30 NM or less and to within the 4 NM zone.

(c) A turn anticipation area shall be constructed at the turn point.

(d) Construction.

1 Points F, T_1, T_2, and J represent the end of section 1. For turns of 90° or less, point C_1 connects to point J. See figure 15-31. For turns of more than 90°, point C_1 of section 3 connects to point T_2. See figure 15-32.

2 The radius for the obstruction boundary is measured from a base line at the latest point the turn WP can be received.

3 The outside primary and secondary area boundaries of the turn connect abeam the plotted position of the turn WP. See figures 15-31 and 15-32.

(3) RNAV Direct Procedure. For an RNAV direct missed approach, the end of section 1 is based on a climb to altitude, and secondary area reductions are not applied.

(a) The end of section 1 is established as described in paragraph 1531a(2)(c). Positive course guidance is not assumed, and secondary area obstruction clearance may not be applied. The end of section 1 is represented by line H-T_3. See figure 15-33.

(b) Construction.

1 A base line extension of line G-D-C separates sections 2 and 3. When point C_1 is established prior to the base line, C_1 connects to point C. See figure 15-33.

2 When C_1 is established beyond the base line, but inside line G-Z, C_1 connects to point G. G-Z is established parallel to the final approach course line. See figure 15-30.

3 When point C_1 is established beyond an area of line G-Z, C_1 connects to point H. See figure 15-35.

4 When point C_1 is established beyond an area of line H-Z, C_1 connects to point K, a tangent point on the boundary arc. H-Z is established paralled to the final approach course line. See figure 15-36.

b. Obstruction Clearance.

(1) RNAV route missed approach of turns 90° or less.

(a) Obstacles in section 2 are evaluated based on the shortest distance in the primary area from the obstacle to any point on line T_2-T_3. See figure 15-31.

(b) Obstacles in section 2b are evaluated based on the shortest distance in the primary area from the obstacle to point T_3 through point J. See figure 15-31.

(2) RNAV Route Missed Approach of Turns More than 90°. Obstacles in sections 2 and 3 are evaluated based on the shortest distance in the primary area from the obstacle to any point on line T_2-T_3. See figure 15-32.

(3) RNAV Direct Procedure. Obstacles in section 2 are evaluated based on the shortest distance from the obstacle to any point on line G-H-T_3-X. Obstacles in section 3 are evaluated based on shortest distance from the obstacle to point X. See figure 15-36.

(4) The height of the missed approach surface over an obstacle in section 2 is determined by measuring the shortest distance from the obstacle to the nearest point on the T_2-T_3 line for RNAV routes missed approach procedures and to the nearest point on the G-H-T_3-X line for RNAV direct missed approach procedures. Compute the height of the surface by using the 40:1 ratio from the height of the missed approach obstacle surface at the end of section 1. The height of the obstacle surface at the end of section 1 is determined by computing the 40:1 obstacle surface slope beginning at the height of the missed approach surface measured from the latest point of the MAP. See figures 15-32 and 15-36.

(5) The height of the missed approach surface over line T_2-T_3 for section 3 computations is the height of the MDA less adjustments in paragraphs 323a, b, and c, plus a 40:1 rise in section 1. See figure 15-32.

(6) The height of the missed approach surface over point X for section 3 computations is the height of MDA less adjustments in paragraphs 323a, b, and c, plus a 40:1 rise in section 1 as measured from line A-B to end of section 1. See figure 15-36.

1536. CLEARANCE LIMIT. The missed approach procedure shall specify an appropriate fix as a clearance limit. The fix shall be suitable for holding. For VOR/DME systems, the clearance limit WP's shall meet terminal fix displacement area criteria from table 15-1. For non-VOR/DME systems, clearance limit WP's shall meet en route fix displacement tolerance criteria from table 15-3.

1537.-1539. RESERVED.

SECTION 4. APPROACH MINIMUMS

1540. APPROACH MINIMUMS. Chapter 3, section 3, applies except that table 6A criteria relating minimum visibility to a distance from the station shall be applied as a variation of crosstrack fix displacement tolerance of the plotted position of the MAP shown in table 15-5. Crosstrack values in table 15-2 shall be applied for VOR/DME. A crosstrack value of 0.6 NM shall be applied for non-VOR/DME.

1541.-1599. RESERVED.

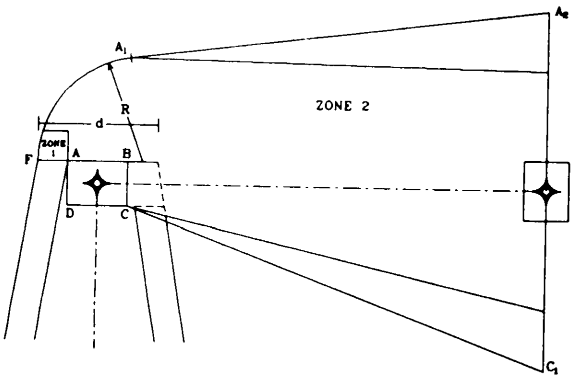


Figure 15-25 RNAV. TURNING MISSED APPROACH, 90° OR LESS. Paragraph 1534a(2)(b).

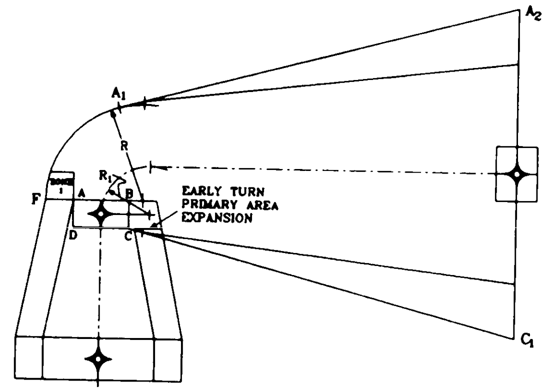


Figure 15-27. DIRECT TURNING MISSED APPROACH, ≤ 90° TIE-BACK POINT C_1 TO POINT C. Paragraph 1534a(2)(b).

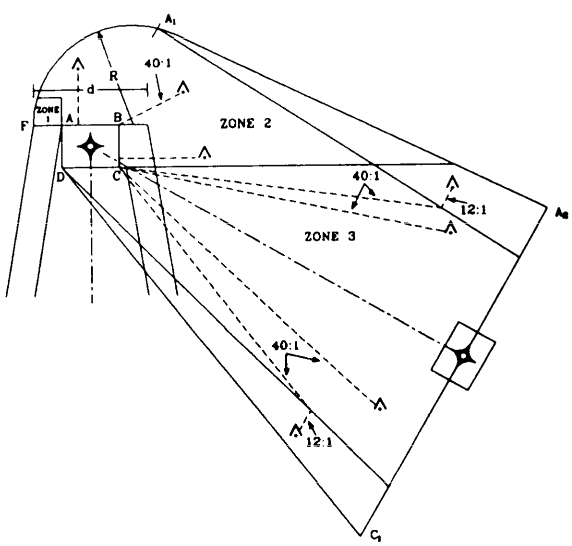


Figure 15-26. RNAV TURNING MISSED APPROACH, MORE THAN 90° UP TO 120°. Paragraph 1534a(2)(b).

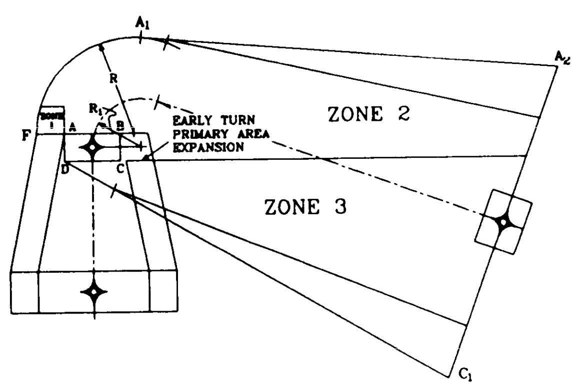
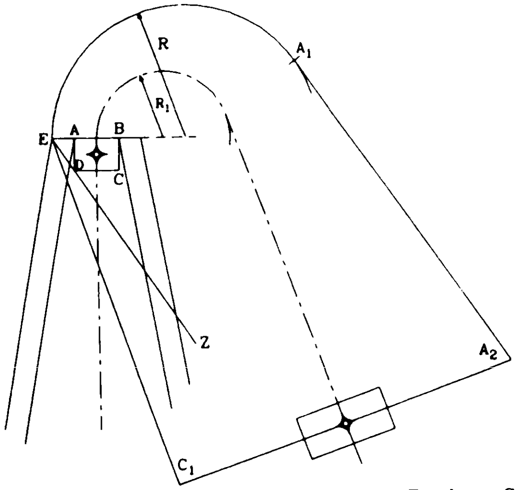


Figure 15-28. DIRECT TURNING MISSED APPROACH, > 90° TIE-BACK POINT C_1 TO POINT D. Paragraph 1534a(2)(b).



NOTE: Point C_1 connects to point E when C_1-E is outside of line E-Z. E-Z is established by drawing an extended line through D and E.

Figure 15-29. DIRECT TURNING MISSED APPROACH, > 90°. Paragraph 1534a(2)(b).

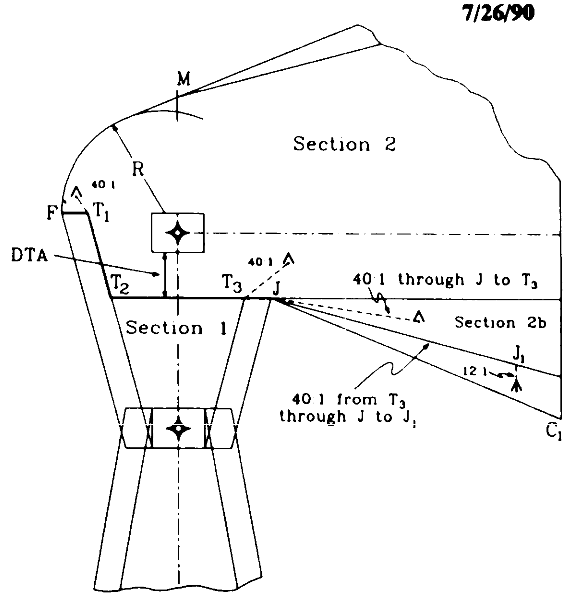
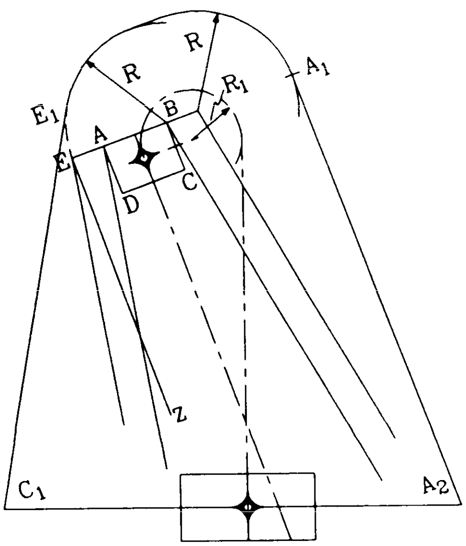


Figure 15-31. RNAV COMBINATION STRAIGHT AND TURNING MISSED APPROACH 90° TURN OR LESS. Paragraphs 1535a(2) and 1535b(1)(b).



NOTE: Point C_1 connects to E_1 tangent to arc when line C_1-E_1 is outside of line E-Z. E-Z is established parallel to final approach course line.

Figure 15-30. DIRECT TURNING MISSED APPROACH > 180°. Paragraph 1534a(2)(b).

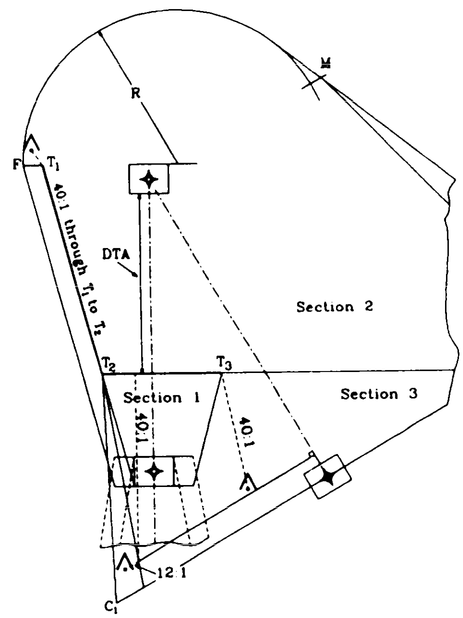


Figure 15-32. RNAV COMBINATION STRAIGHT AND TURNING MISSED APPROACH. MORE THAN 90° UP TO 120°. Paragraph 1535a(2).

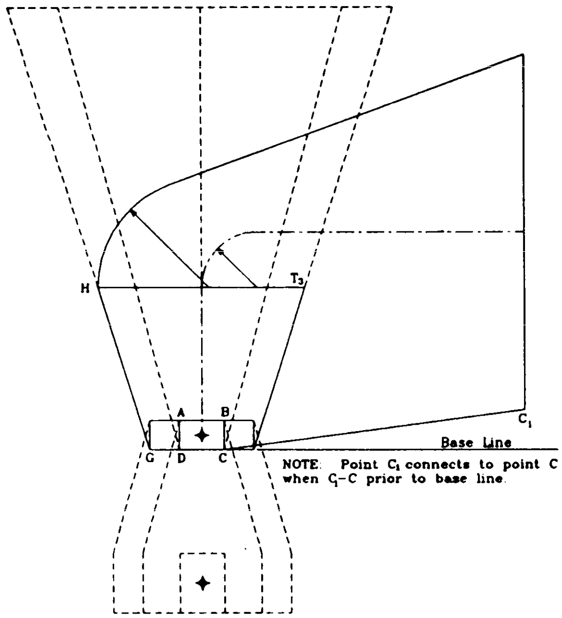


Figure 15-33. CLIMB TO ALTITUDE, STRAIGHT AND TURNING MISSED, C_1 PRIOR TO BASE LINE.

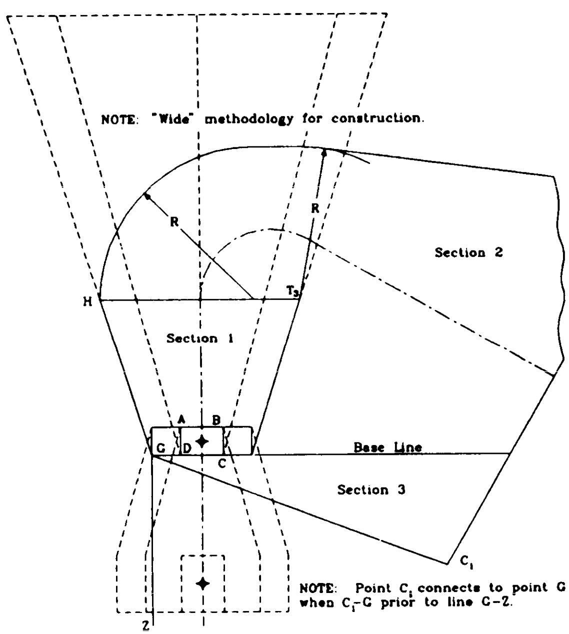


Figure 15-34. CLIMB TO ALTITUDE, STRAIGHT AND TURNING MISSED APPROACH > 90°. Paragraph 1535a(3).

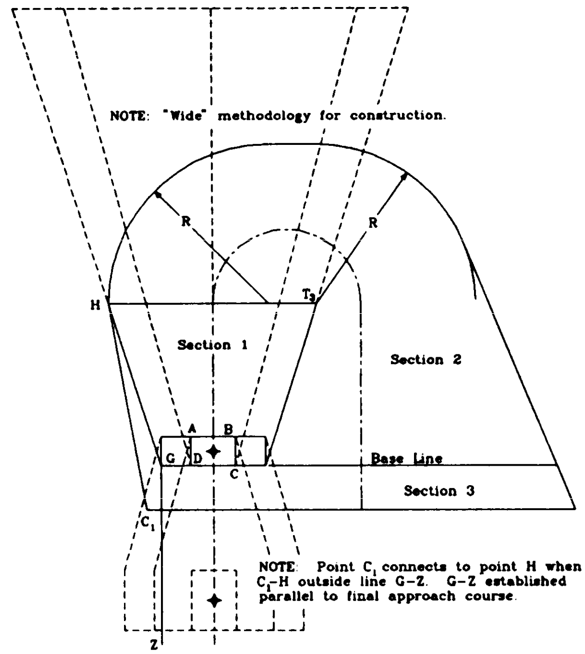


Figure 15-35. CLIMB TO ALTITUDE, STRAIGHT AND TURNING MISSED APPROACH > 90°. Paragraph 1535a(3).

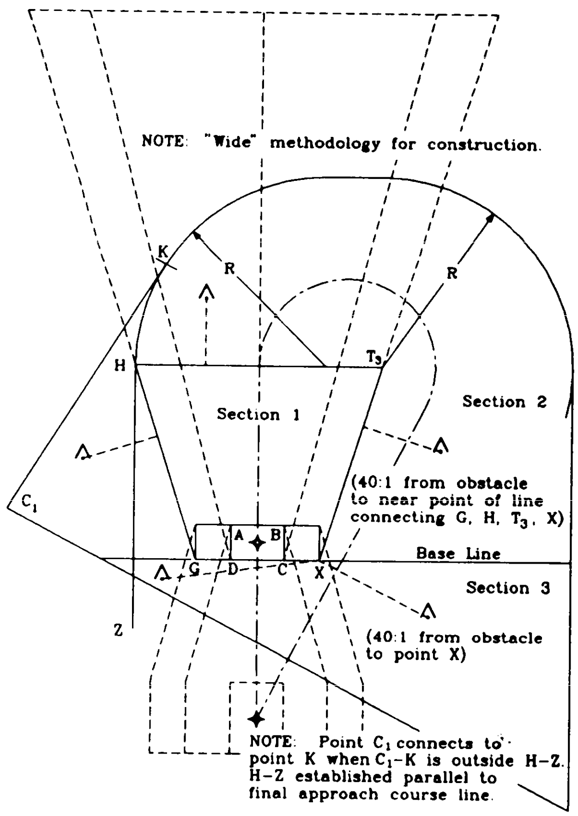


Figure 15-36. CLIMB TO ALTITUDE, STRAIGHT AND TURNING MISSED APPROACH > 180°. Paragraph 1535a(3).

Table 15-1
VOR/DME EN ROUTE AND TERMINAL FIX DISPLACEMENT TOLERANCE

FIX DISTANCE ALONGTRACK FROM TANGENT POINT

DISTANCE FROM TANGENT POINT TO VOR/DME

Terminal

		0	10	20	30	40	50	51
0	XTRK		1.3	1.7	2.2	2.8	3.4	3.5
	ATRK		0.6	0.6	0.7	0.8	0.9	0.9
10	XTRK	1.2	1.3	1.7	2.2	2.8	3.4	
	ATRK	0.8	0.8	0.9	0.9	1.0	1.1	
20	XTRK	1.2	1.4	1.8	2.3	2.8		
	ATRK	1.3	1.3	1.3	1.4	1.4		
30	XTRK	1.2	1.4	1.8	2.3	2.9		
	ATRK	1.8	1.8	1.9	1.9	2.0		
40	XTRK	1.3	1.5	1.8	2.3			
	ATRK	2.4	2.4	2.4	2.4			
50	XTRK	1.3	1.5					
	ATRK	2.9	3.0					
53	XTRK	1.3						
	ATRK	3.1						

Table may be interpolated -- or use next higher value.
XTRK/ATRK values are ±

J/V En Route (rows 0–70, columns 0–40) / **Random En Route** (all rows and columns)

		0	10	20	30	40	50
0	XTRK		1.3	1.7	2.2	2.8	3.4
	ATRK		0.6	0.6	0.7	0.8	0.9
10	XTRK	1.2	1.3	1.7	2.2	2.8	3.4
	ATRK	0.8	0.8	0.9	0.9	1.0	1.1
20	XTRK	1.2	1.4	1.8	2.3	2.8	3.4
	ATRK	1.3	1.3	1.3	1.4	1.4	1.5
30	XTRK	1.2	1.4	1.8	2.3	2.9	3.5
	ATRK	1.8	1.8	1.9	1.9	2.0	2.0
40	XTRK	1.3	1.5	1.8	2.3	2.9	3.5
	ATRK	2.4	2.4	2.4	2.4	2.5	2.5
50	XTRK	1.3	1.5	1.9	2.4	2.9	3.5
	ATRK	2.9	3.0	3.0	3.0	3.0	3.1
60	XTRK	1.4	1.6	1.9	2.4	3.0	3.6
	ATRK	3.5	3.5	3.5	3.6	3.6	3.6
70	XTRK	1.4	1.6	2.0	2.5	3.0	3.6
	ATRK	4.1	4.1	4.1	4.1	4.2	4.2
80	XTRK	1.5	1.7	2.1	2.5	3.1	3.6
	ATRK	4.6	4.7	4.7	4.7	4.7	4.8
90	XTRK	1.6	1.8	2.1	2.6	3.1	3.7
	ATRK	5.2	5.2	5.3	5.3	5.3	5.3
100	XTRK	1.7	1.8	2.2	2.6	3.2	3.7
	ATRK	5.8	5.8	5.8	5.9	5.9	5.9
110	XTRK	1.7	1.9	2.2	2.7	3.2	3.8
	ATRK	6.4	6.4	6.4	6.4	6.5	6.5
120	XTRK	1.8	2.0	2.3	2.8	3.3	3.8
	ATRK	6.9	7.0	7.0	7.0	7.0	7.1

Table application per segment

Segment	Table 15-1 J/V En Route	Table 15-1 Random En Route	Table 15-1 Terminal
En Route	X		
Feeder		X	
Feeder S/D		X	
IAWP			X
Initial S/D			X
IWP			X
Intermediate S/D			X
MA/Holding			X

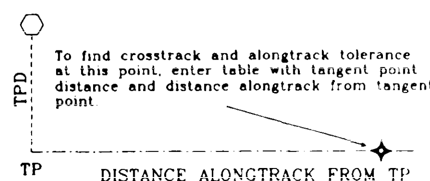


Table 15-2
FINAL/MISSED AREA FIX DISPLACEMENT TOLERANCE

FIX DISTANCE ALONGTRACK FROM TANGENT POINT

TANGENT POINT DISTANCE (TPD) FINAL/MISSED		0	1	2	3	4	5	10	15	20	25	30
0	XTRK		0.7	0.7	0.7	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7
1	XTRK	0.7	0.7	0.7	0.7	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7
2	XTRK	0.7	0.7	0.7	0.7	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7
3	XTRK	0.7	0.7	0.8	0.8	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7
4	XTRK	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8
5	XTRK	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8
10	XTRK	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9
15	XTRK	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.2	1.5	1.8	2.1
	ATRK	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2
20	XTRK	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.3	1.5	1.8	2.1
	ATRK	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4
25	XTRK	0.8	0.9	0.9	0.9	0.9	0.9	1.1	1.3	1.6	1.8	2.1
	ATRK	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6
30	XTRK	0.9	0.9	0.9	0.9	0.9	0.9	1.1	1.3	1.6	1.9	2.1
	ATRK	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9

INTERPOLATE TO THE NEAREST 0.1 MILE
XTRK/ATRK values are ±

Table application per segment

Segment	Table 15-2
En Route	
Feeder	
Feeder S/D	
IAWP	
Initial S/D	
IWP	
Intermediate S/D	
FAWP/ATD Fix	X
Final S/D	X
MAWP/ATD Fix	x
RWY WP/APT WP	X
MA Turn Point	X
MA/Holding	

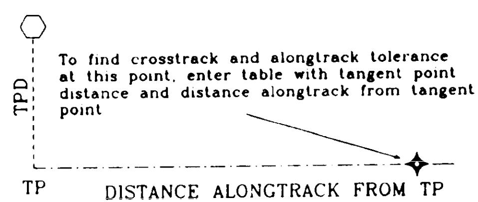


Table 15-3
NON-VOR/DME FIX DISPLACEMENT TOLERANCE

	EN ROUTE	TERMINAL	APPROACH
XTRK	3.0	2.0	0.6
ATRK	2.8	1.7	0.3

XTRK/ATRK values are ±

Table application per segment

	TABLE 15-3		
Segment:	En Route	Terminal	Approach
En Route	X		
Feeder	X		
Feeder S/D	X		
IAWP		X	
Initial S/D		X	
IWP		X	
Intermediate S/D		X	
FAWP/ATD Fix			X
Final S/D			X
MAWP/ATD Fix			X
RWY WP/APT WP			X
MA Turn Point			X
MA Holding	X		

Table 15-4
MINIMUM LENGTH OF FINAL APPROACH SEGMENT (NM)

APPROACH CATEGORY	MAGNITUDE OF TURN OVER THE FINAL APPROACH WAYPOINT (FAWP)		
	0°-5°	>5°-10°	>10°-30°
A	1.8	1.8	2.0
B	1.8	2.0	2.5
C	2.0	2.5	3.0
D	2.5	3.0	3.5
E	3.0	3.5	4.0

Table 15-5
EFFECT OF CROSSTRACK TOLERANCE
ON VISIBILITY MINIMUMS

	CROSSTRACK TOLERANCE (NM)				
CATEGORY	0.6 - 0.8	>0.8 - 1.0	>1.0 - 1.2	>1.2 - 1.6	>1.6
A	1	1	1	1	1
B	1	1	1	1.25	1.25
C	1	1	1.25	1.5	1.5
D	1	1.25	1.5	1.75	2
E	1	1.25	1.5	1.75	2

Table 15-6. MINIMUM LEG LENGTH FROM MAP TO NEXT WP
USING RNAV MISSED APPROACH PROCEDURE. *

	Course Change at MAP				
CAT	>15° ≤30°	≤45°	≤60°	≤90°	≤120°
	Minimum Leg Length, NM, between MAP and next WP				
A	3.0	4.0	5.0	5.9	6.9
B	3.0	4.0	5.2	6.2	7.2
C	3.0	4.2	5.5	6.5	7.6
D	3.0	4.5	6.0	7.3	8.5
E	3.0	5.5	7.8	9.5	11.3

*